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DEVELOPMENT AND TESTING OF AN EXPERIMENTAL POLYSENSORY INSTRUCTIONAL SYSTEM FOR TEACHING ELECTRIC ARC WELDING PROCESSES. REPORT NO. 24, FINAL REPORT.

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The population of the study consisted of 15 high school industrial arts students, 10 freshman and sophomore college students, and 10 adults. A polysensory, self-pacing instructional system was developed which included (1) pretests and post tests, (2) a general instruction book, (3) equipment to practice arc welding, (4) programed instruction books, (5) loop films for demonstrating arc welding procedure, and (6) self-evaluation devices. Subjects were administered pretests to determine facts and skills possessed before using the system. General directions were given about the use of the system and the subjects proceeded at their own pace and repeated phases of work as often as necessary to produce a weld of quality predetermined as satisfactory by a jury of experts. Analysis of variance was used to test the significance of the differences between the performance of the groups. All subjects acquired levels of knowledge and performance which were predetermined as satisfactory. The average time required to reach this level was 5 hours and 10 minutes, with the high school students using more time than the other groups. Results indicate the practicability of utilizing polysensory instructional systems for learning high level perceptual-motor skills and knowledge. The system should be tested with controlled groups to ascertain the strength of this approach of instruction. (HC)

C/

FINAL REPORT
Project No. OE7-0031
Contract No. OEG-4-7-070031-1626
Report No. 24

DEVELOPMENT AND TESTING OF AN EXPERIMENTAL POLYSENSORY INSTRUCTIONAL SYSTEM FOR TEACHING ELECTRIC ARC WELDING PROCESSES

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Washington

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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SUMMARY

Purpose

The purpose of this study was to ascertain the extent to which a polysensory, self-pacing instructional system is effective in teaching concepts and high level perceptual-motor skills involved in electric arc welding. The study sought to ascertain variations in amounts of time and repetition pupils of various ages and abilities required to reach defined levels of knowledge and skill. It also identified points at which students experience difficulty in the use of the system and ways the system can be improved.

Population

Population of this study consisted of 15 high school industrial arts students, 10 freshman and sophomore college students, and 10 adults. High school and college students were classified into low, average, and high ability categories. Scores on numerical and verbal sections of the School and College Ability Tests and the Differential Aptitude Tests were used as ability measures.

Procedure

A polysensory, self-pacing instructional system was developed. The system was comprised of six components -- pretests and posttests, a general instruction book, equipment to practice arc welding, programmed instruction books, loop films demonstrating arc welding procedures, and self-evaluation devices.

All subjects were administered pretests to determine facts and skills each possessed before using the system.

Subjects were given general direction about use of the system and were then directed to proceed at their own pace and to repeat phases of work as often as they deemed necessary to produce a weld of a quality predetermined as satisfactory by a jury of experts.

Performance scores, errors made, frequency of film viewing, and time used to complete the system were recorded on frequency tables to show differences between the performance of high school, college, and adult groups of various ability levels. Analysis of variance was used to test the significance of the difference between means of time used to complete the system by the high school, college, and adult groups.

Results

All subjects acquired levels of knowledge and performance predetermined as satisfactory by the jury of welding experts.

High school students used more time than college and adult students to complete the system but the difference between mean times of the college and adult groups was statistically insignificant.

Time necessary for individual subjects to reach satisfactory levels of performance ranged from 3 hours and 30 minutes to 13 hours, 10 minutes. The average was 5 hours and 10 minutes.

Time used to complete the instructional system varied extensively between and within ability levels and groups. College and adult groups required less time than the high school group to complete the instructional system.

Frequency of film viewing varied between and within groups. The adult group viewed the films least often. In the high school group, high ability level students viewed the films most often.

Errors in use of programmed instruction books varied. The high school group made 14 errors; the college group made no errors; and the adult group made two errors.

Results of checkup review tests indicated that all participants gained in knowledge. Numbers of errors were similar for different groups and for students with various ability levels.

CHAPTER I

STATEMENT OF THE PROBLEM

The purpose of this study is to ascertain the extent to which a polysensory instructional system is effective in teaching concepts and high level perceptual-motor skills involved in electric arc welding. The following evidence was sought.

1. How much time is needed for students of various ages with various levels of learning capabilities to acquire defined levels of knowledge and skill from use of the system?
2. How much repetition of film viewing is necessary for acquisition of defined levels of knowledge and skill?
3. At what points do students experience difficulty in the use of the system?
4. In what ways can the system be improved?

Significance of the Study

Studies show that when several senses are involved, learning is greatly enhanced.[1] This study is an attempt to provide additional information about the capability of a polysensory instructional system to enable three groups of students to acquire knowledge and to develop prescribed levels of perceptual-motor skills. The groups are high school students, freshmen and sophomore college students, and adults. This study also provides additional information about the capability of a polysensory instructional system to enable students having three levels of ability (low, average, and high) to acquire prescribed levels of knowledge and perceptual-motor skills.

Background of the Study

During the Fifteenth and Sixteenth Centuries, books began to make information and ideas more generally available. Since then, there have been many significant developments in educational technology. The first sound motion picture for classroom use was developed in 1929. In the intervening years motion pictures have developed rapidly. In addition new developments in printing and television have enlarged potentials for more effective instruction.

Use of these technological capabilities has been given impetus by the social and economic forces. Such forces include rapid technological change, the growth of knowledge, the civil rights movement, and growing urbanization. Expanding school enrollment, dropouts, and youth problems are increasing the need for teachers and more efficient means of instruction. Concern for national defense adds pressure for educational improvements.

Other forces affecting education include federal educational programs which are shaped from aroused public concern for the rights of the individuals, poverty, vocational, and professional education.

Pressure to improve education is also coming from a growing demand for continuing adult education. Technological progress requires frequent retraining of skills for workers, and earlier retirement has developed a new need for adult education.

The changing picture of American education creates new challenges and opportunities for educators. Modern developments of vocational-technical curricula and a substantial increase in the number of vocational-technical students require the utilization of educational technology to meet the needs of this ever increasing group of students. According to Slaughter, "the potential contribution of technology to education is enormous . . . and will depend upon the research and development effort put behind the planning and production of systems of technology."[2]

The potential contribution of technology to educational needs will be governed in part by effectiveness of research. To be effective, a research and development program requires clearly defined objectives to delineate the direction of the research. Slaughter states:

> Educational technology is not just destined to grow It seems likely to grow in certain directions. One unmistakable direction will be the development of educational technology on a systems basis, with close and direct relevance to the purposes of education and objectives of instructions and with a maximum contribution being made by each component of the technology to the end result obtained in the system. Claims for the system will be supported by research and experimental results.[3]

One such development is exemplified by the polysensory system concept. This concept shows promise of providing a broader base in course development and new opportunity for use of combinations of communication aids which are not fully utilized at present.

Essence of Polysensory Instructional System

The concept of polysensory instructional systems implies use of several types of stimuli to involve various senses in the learning process. This is accomplished by using combinations of media and practice to guide learning.

McPherson notes that a systems approach to instruction has three basic characteristics.[4] First, it requires an ecological approach. Subject areas must be related to each other as fully as possible and methods and materials used must represent an application of the best means of giving an individual the kinds of experiences most likely to result in desired learnings. The central purpose is to make all of education a systematic whole for learners. Various specialists can contribute to such systems.

A second element of a system is a requirement for a detailed analysis of learning objectives specific to the subject field and to learner. Other elements include identification of the kinds of learning activities to be carried on to gain objectives and the methods and media which will enable learners to engage in appropriate learning activities.

A third characteristic of a system as defined by McPherson requires learning resources be secured and/or produced and organized into an arrangement which makes it possible for learners to engage in activities required to reach learning objectives. This implies experimental development of a system of learning resources, appraisal of its use, and redesign until learning gains are satisfactory.

The systems approach offers a scientific method for organization, statement, and derivation of alternative possible solutions to the many problems of instruction. Eight design requirements and classifications for system development have been proposed by Robert E. Corrigan.[5]

1. Statement of objectives for instruction and individual learning expressed in performance terms.

2. Determination of the essential (minimal) subject matter to meet the stated objectives.

3. Ordering of subject matter into a program format designed to expedite the learning objectives.

4. Highly individualized student participation on a continuously active basis featuring the recurrent requirement for overt, observable responses to strengthen the learning process and to evaluate student achievement.

5. Controlled pacing of instruction consistent with student performance as measured by the pre-established criteria of learning.

6. Highly directed communication by the "instructor" (media) using the "tutorial" or "coach-pupil" two-way communication model to insure continual and purposeful interaction between "instructor and student."

7. Incorporation throughout the system of those fundamental principles essential to efficient learning, such as:

    a. knowledge of results of performance
    b. immediate correction of incorrect response
    c. purposeful repetition and reinforcement scheduling
    d. directing the student in purposeful learning sequences with his prior knowledge of learning objective present and future.

8. Statement of interim and final performance requirements and measures.

For a better understanding of the systems, it will help to examine what happens when a student learns by use of such instruction. Haizlip explains:

> First the student masters information in small steps. Each step presents a carefully sequenced unit of information such as a rule, definition, example, illustration, or fact which builds tightly on the preceding materials.
>
> He then utilizes this new material in making an active response. The step or part that teaches also asks him to complete a sentence, select a correct alternative, give an example, complete a diagram, or some other overt response. Making this response is not difficult in itself, but it guarantees that attention will be paid to significant information.
>
> Finally, the student is presented with immediate confirmation or feedback in the form of the correct answer. In a teaching machine, the correct answer may come to view when a knob is turned; with programmed instruction the student might turn the page to reveal the correct response; or the student might compare his result with correct examples or solutions. This technique permits new learning to be reinforced immediately and corrects wrong responses before learning proceeds on false premises.[6]

Good systems of instruction are carefully designed, produced, tested, and then revised. When errors accumulate, the system is inadequate. A study of the wrong responses will reveal inadequacies and corrective changes can then be made. Systems developed in this manner may be used by students with relatively few errors.

Systems of instruction can be self-pacing, and each learner can advance at his own best rate. In contrast to the relatively fixed pace of the traditional classroom, both slow and fast learners work at appropriate paces without undue pressure or waste of time. An assignment which a fast learner might finish in six hours may require fifteen hours for a slower one. Yet both can reach similar levels of achievement.

Conventional classroom teaching is often aimed at a hypothetical average student who, in fact, may not exist. In such cases, the rapid learner is held back while the slow learner cannot keep up. Few students have a chance to respond in any given session, and the teacher may favor those who are most able to respond verbally. In contrast, systems instruction is learner-centered, encouraging each student to work at his best rate. Such individualization permits the student to pause for reflection without penalty.

There are other functions appurtenant to a polysensory system which may have future influence on educational achievement. Some of these functions are:

1. Relieving the teacher of functions that can be performed by other media so that they can devote their time and talent to teaching responsibilities that require personal professional services.

2. Helping each student to achieve for himself the full realization of his talent and capacity for education by providing instruction where it is needed, and when it is needed.

3. Utilizing the reinforcement principle of learning.

4. Providing more flexibility in educational organization and process.

5. Enlarging the self-instructional dimension and means of helping pupils acquire information and performance capabilities.

Definition of Terms

Polysensory Instructional System

A polysensory instructional system consists of a combination of instructional materials and processes with each component making a maximum contribution to specified educational objectives. The system emphasizes utilization of as many senses of the student as is feasible to maximize learning and to facilitate instruction.

Instruction Book

The Instruction Book utilizes programed instruction to reinforce the learning of knowledges and skills shown in the films.

In the books prepared for use in this study a fact is presented and then followed by an incomplete sentence relating to the fact. The student is directed to correctly complete each sentence by writing words in the spaces provided. Correct answers are shown on the back of each page for immediate reinforcement. A review test is provided at the end of each programed instruction unit. If the student encounters difficulty while completing a test, he is directed to review the films and appropriate parts of the instruction book. When he can answer all test items correctly, he proceeds to practice as directed.

Single-Concept Loop Film

The films developed for this study utilize both color and sound. They are continuous film loops enclosed in plastic cartridges. The student can independently view each film as often as necessary without rewinding. The films show basic knowledges and skills necessary to join two pieces of steel by arc welding. The comments recorded on the films explain the facts, principles, and procedures that are illustrated.

High Level Perceptual-Motor Skill

This is a learned muscular movement of advanced complexity acquired as a result of responding to sensory stimulus. High level perceptual-motor skills require a constant surveillance and concentration for instantaneous reaction to varying stimulus cues generated by overt responses. In learning high level perceptual-motor skills for electric arc welding, it is imperative that the student adjust his overt responses to cues that are developed while the welding operation is occurring. These cues result from the student manipulating the electric welding arc in certain ways. When his manipulations result in development of correct cues, a satisfactory weld is formed. When the manipulations result in unsatisfactory cues, the student must recognize them and adjust his overt responses to create correct cues and a satisfactory weld.

Practice Sessions (Skill Development)

Practice sessions with electric arc welding equipment were arranged to provide the student with opportunity for application of knowledge and development of skills described by the films and programed instruction books.

Practice sessions were designed to give students experience with each of the four basic processes. Upon completion of programed instruction for each part of this unit, the student was directed to practice in a manner similar to processes shown in the films.

Safe and proper use of equipment was required at all times. Such use is illustrated by the films previously viewed by the student.

Satisfactory Performance

Satisfactory performance is obtained when a student's proficiency level corresponds with the criteria established by a jury of welding specialists. Student performance is evaluated by comparison of the quality of his welds with those illustrated on performance checklists.

High Ability

High school students whose total scores are from 75 to 100 percentile on the Numerical and Verbal Sections of the Differential Aptitude Test (Form L) or on the Verbal and Quantitative Sections of the School and College Ability Tests (Form 2A) are classed as high ability.

College students whose composite scores are from 78 to 100 percentile on the Verbal and Quantitative Washington Pre-College Test Battery are classed as high ability.

Average Ability

High school students whose total scores are from 26 to 74 percentile on the Numerical and Verbal Sections of the Differential Aptitude Test (Form L) or on the Verbal and Quantitative Sections of the School and College Ability Tests (Form 2A) are classed as average ability.

College students whose composite scores are from 24 to 77 percentile on the Verbal and Quantitative Washington Pre-College Test Battery are classed as average ability.

Low Ability

High school students whose total scores are from 0 to 25 percentile on the Numerical and Verbal Sections of the Differential Aptitude Test (Form L) or on the Verbal and Quantitative Sections of the School and College Ability Tests (Form 2A) are classed as low ability.

College students whose composite scores are from 0 to 23 percentile on the Verbal and Quantitative Washington Pre-College Test Battery are classed as low ability.

Footnote References -- Chapter I

[1] Robert M. Gagné (ed.), The Conditions of Learning (New York: Holt, Rinehart and Winston, Inc., 1965).

[2] Robert E. Slaughter, Technology in Education (Washington, D.C.: U.S. Government Printing Office, 1966), p. 4.

[3] *Ibid.*, p. 6.

[4] J.J. McPherson, "Let's Look at the Systems Concept of Educational Planning," Educational Media Branch, Office of Education, U.S. Office of Health, Education, and Welfare, Washington, D.C. (n.d.), pp. 2-4.

[5] Robert E. Corrigan, "Programmed Instruction as a Systems Approach to Instruction," Trends in Programmed Instruction, ed. Gabriel D. Ofiesh and Wesley C. Meierhenry, Department of Audio-visual Instruction (Washington, D.C.: National Education Association, 1964), p. 38.

[6] Harold C. Haizlip, Technology in Education (Washington, D.C.: U.S. Government Printing Office, 1966), p. 35.

CHAPTER II

REVIEW OF RELATED DEVELOPMENTS AND RESEARCH

Five centuries ago when the first book was printed with movable type, the foundation was laid for major developments in education. Education today is facing another forward surge. The electronic age is changing our traditional notions of education. The role of the teacher and the nature of the learning process must be re-examined in the light of new educational technology.

Burns suggests that programs for using the new technology should consider the best uses of devices such as:

1. Centralized tape libraries from which local school systems could select, for example, an entire course of instruction or specialized lectures prepared by the greatest teachers in specific fields.

2. Closed-circuit TV systems for a school district or region and individual video tape players--the hear-and-see devices--to enable each classroom to utilize the course materials that can be made available to every school.

3. Electronic teaching machines that have been particularly successful in language instruction.

4. Programmed learning systems for detailed, repetitive instruction.

5. Scanning devices in each classroom that would be linked to the library and records office to free teachers from many routine functions.

6. Computer centers for grading examinations for a school or an entire school district relieving teachers of a time-consuming chore.

7. Computers for cataloging and retrieving information.

8. A flexible open-circuit educational TV network to bring a variety of current-events type instruction to classrooms.[1]

Burns proposes that to obtain maximum use of these and other devices, systems of instruction might be developed.[2]

According to Slaughter:

> The realization of the potential contribution of technology to education will depend upon the perspectives and successful development of systems of technology, in which each component in nature and function as a part of the system makes a synergistic contribution to the total result obtained by the system.[3]

Specialists in the analysis and design of systems vary in their definitions of system or system design. A definition presented by Donald Stewart provides a comprehensive version for use here. He states:

> A learning systems approach is an effort to organize and condense those necessary or desired experiences as concisely and systematically as possible so as to increase the probability that learning will occur in an efficient manner. A Learning Systems concept, when applied to educational or training courses, offers an opportunity to develop or rebuild these courses to be significantly more effective and efficient in relation to the learning tasks and goals of the students.[4]

Canfield explains:

> The systems approach to instruction embodies the major characteristics of any system; specifically defined objectives; detailed plans for their achievement in identifying all crucial elements and their interreactions; and continued feedback.[5]

Corrigan proposes:

> System requirements are postulated to organize and develop the methods and materials of instruction including automatic teaching most consistent with efficient individual learning requirements in both individual and group settings. The underlying philosophy of this system provides the most meaningful rationale to organize, coordinate and direct the efforts of all contributing groups.[6]

The concept of a systematic approach to the management of learning is not new. However, the burgeoning field of instructional technology has opened the way for many alternative instructional patterns. In developing a system of instruction, Egbert suggests that the following steps be followed:

1. As a first step to guide the development of systems for schools, operational goals must be stated. Furthermore, priorities must be attached to those goals to enable the system designer to plan effectively.

2. The second step is to produce a descriptive model of the system. The system thus stated must be so designed as to permit achieving the stated goals. Thus, the initial description must be "ideal" oriented and must be divorced from restrictions imposed by reality. To ensure internal consistency and to permit close analysis of the plan, logical flow diagrams must be constructed.

3. Step three involves computer simulation of the model. This simulation should include representation of students, school personnel, curriculum, space, and equipment and should examine various operating rules. Computer simulation will enable manipulation of the model and will give additional information about its characteristics and requirements.

4. Based on experience in simulating the model, a decision must be made whether the model is ready for initial documentation. The making of this decision is indicated as step four.

5. If the model requires changes before documentation is accomplished, the designer moves to step five which calls for making necessary modifications in the model. He then proceeds through another simulation phase.

6. If the simulation study demonstrates that the model is theoretically sound, a document should be prepared detailing personnel and material requirements of the system as represented in this model.

7. With the requirements of an ideal system specified, the next step is to test these requirements against reality--both as to availability of personnel and material and feasibility of applying the program. (By feasibility, we refer to such problems as cost and relationships with school patrons.)

8. The reality test described as step seven provides the basis for another decision--whether the system is ready for implementation. If the system is not ready for implementation, the designer must return again to step five, make modifications to the model and move again through steps three, simulation; five, documenting; and six, reality testing.

9. If the system proves to be ready for field testing, the system designer should attempt tests in schools

representing as wide a range of designs and requirements as possible.[7]

Other writers such as Briggs,[8] Hamblen,[9] Allen,[10] and Gagne[11] seem to agree on the value of basic procedures as noted above when designing a learning system.

Media selection is based primarily on the need to provide stimuli. The polysensory instructional system utilizes multi-media to supply instructional events needed for learning and to provide instructional stimuli required in the correct sensory mode and proper quality.

In the past years numerous studies have tested use of various media for teaching performance skills such as reading, typing, athletic skills, and mechanical assembly of equipment. To achieve the development of skills, demonstrations have been made and presented, then concurrent practices have been provided for learners. Many of these studies were related to the operation of one piece of equipment.

Instruction is composed of stimuli to provide the external conditions for learning. The media selected for this study were those which were expected to be most adequate for presenting stimuli to maximize learning via combinations of the visual, aural, and tactual senses. Therefore, this review of literature has been arranged in three parts: (1) motion picture film research, (2) programmed instruction research, and (3) participation of the student in task performance.

Studies Related to Motion Pictures

Polysensory instruction systems aimed at development of perceptual-motor capabilities may include the use of sound motion pictures.

Research indicates that motion pictures can be effective in teaching both factual information and perceptual-motor skills. Vandermeer and Cogswell[12] successfully used films to teach trainees how to operate a motion-picture projector.

A study by Harby[13] found that demonstrations projected by means of film loops in daylight proved as effective as a live instructive demonstration and that daylight projection of film loops is a practical way of providing on-the-spot film demonstrations in perceptual-motor training.

A study by Murnin, Harby, and Hayes[14] concludes that learning from film did occur to a significant extent. They also found that daylight projection of film loops can teach perceptual-motor skills with an effectiveness approaching that achieved by expert instructors using live demonstrations.

Rimland[15] indicates that in teaching a simple perceptual-motor skill it is better to repeat the same visual presentation of a demonstration. This study lent support to the efficacy of constant repetition as it is used in the projection of short film loops. It was suggested that as the skills become more complex some variation in repetitive presentation of certain phases of the action may be needed in order to introduce additional learning cues, a few at a time.

In training engine lathe operators over a prolonged period Vandermeer[16] found that film instruction cut the working time, resulted in a reduction of the period of trial-and-error learning, and increased learning of factual information. Vandermeer suggested that films are perhaps more effective in teaching the more complex skills than the simple ones.

The results of an experiment by Jaspen[17] to teach an assembly of the breech block of the 40 mm. anti-aircraft gun indicated that a slow rate of development is a most important factor in making a teaching film effective. As new material is introduced in a film it should be covered pictorially at a slow speed that is consistent with other considerations. He found that repetitions of the demonstration of the task will add considerably to teaching effectiveness of a given task, even when the film is otherwise already effective. Jaspen recommended that, in addition to showing right ways to perform a task, film should also point out common errors to be avoided.

Kats[18] and Jaspen[19] found the use of technical nomenclature and adding elements does not facilitate learning and may actually interfere with skill development.

Beck and Lumsdaine[20] in an intersive study used an exploratory comparison of two methods of teaching the assembly and disassembly of a portable radar station. One method of teaching was with a film and the other was with competent instructor using a scale model. The results suggest that film was at least as effective as a comparable lecture-demonstration by a highly competent instructor. It was indicated that the film method would have been much more effective than an average or poor instructor. Further observations were that the film-instructed group performed more as a team and required less on-the-job instruction.

Roschal[21] found the effectiveness of films designed to teach perceptual-motor skills such as knot tying will be improved if the task is portrayed from the viewing angle of the learner as he will perform the act. He also concluded that film showing motion was more effective than a series of static shots for learning of perceptual-motor tasks.

A study conducted by Nelson and Moll[22] deals directly with the relative contributions to learning made by (1) the visual channel, (2) the auditory channel, and (3) the visual and auditory channels combined, in instructional films. The one clear-cut finding is that both the audio and video channels working together are much more effective than either one alone. Evidence indicated that even in films in which the narration contains the greater part of the material to be learned, the visual element is almost as effective in communicating the material as the narration.

The problem of optimum verbalization has been the focal point of several studies. Jaspen[23] found it is possible to have too many or too few words in the narration of an instructional film. The most effective rate was about 100 words per minute.

Zuckerman[24] found that verbal descriptions assist the learner, but when the rate is increased will interfere with and actually reduce learning. He noted that directive statements using the imperative mood or the second person action were most effective in promoting learning. He also concluded that where the learner must be alerted to a relationship or detail to be presented on the screen, some advance direction in terms of commentary "lead" is desirable.

A study by Rimland[25] indicated that a medium level of verbalization was probably more effective than a much higher or lower level.

In a study of the affect of attention-gaining devices on film-mediated learning Neu[26] found that where instruction is the principal aim, producers should present the subject matter in a simple, straightforward way, and avoid the use of such fancy and expensive devices as spotlighting, zooms, extreme magnification, and stop motion, to gain the learner's attention.

A study conducted by McNiven[27] investigated effects on learning of the perceived usefulness of the material to be learned. He found the nearer the individual perceives himself to be to the use of information from a film, the greater will be the learning.

Studies of Programed Instruction

Programed instruction is an element of learning systems arousing much current interest and research. Articles relating to programed instruction have appeared in psychological, educational, and industrial journals over the past few years. Many programs in various subjects have been developed, tested, and are being used. A review of some such studies will contribute an understanding of programed instruction as it is used in this system. Most of the studies compare similarities and differences of programed instruction and traditional methods of instruction.

Schramm states:

> There has been a considerable amount of research on programed instruction--probably somewhere near 100 experiments. Indeed, no teaching medium has ever come into use in such an atmosphere of research.[28]

He continues:

> This research leaves us in no doubt that programs do teach. A great deal of learning seems to take place, regardless of the kind of program or the kind of students. Even a bad program is a pretty good teacher. Programs have been used successfully at all levels of the educational system, at all levels of ability from slow learners to the very best students, and to teach a great variety of academic subject matter and verbal and manual skills.
>
> We can accept confidently, therefore, the conclusions that programs do teach. But how they teach, and what combinations of characteristics make them teach better, is still much in doubt.[29]

Schramm adds:

> One cannot help but notice the incompleteness of the research on the effective forms of programed instruction. It must be admitted that, as of now, the reported literature really gives all too little guide to programers who would do a superior job. For the most part, the research on which a programer must chiefly rely is his own empirical study of the way his first test subjects respond to his program; those five, or six, or ten test cases, he may find more helpful than the same number of formal articles.[30]

Two basic styles of programming are commonly used. Goldstein[31] describes them as (1) linear programs and (2) "intrinsic" programs. In the linear program as developed by Skinner a constructed response type of frame is used. The material is presented in small bits or steps in a logical sequence in which each succeeding frame is in some way related to the preceeding frame or frames. Within each frame the learner is required to make a constructed response to the stimulus material. After the learner's response has been made, the correct answer is revealed to him.

In "intrinsic" programming as developed by Crowder, the learner is presented with as many as three or four paragraphs of material to read within one frame. He then is required to make a response by choosing the correct answer from a given multiple choice. If the learner chooses correctly, he is sent on to the next frame. If he selects an incorrect response, he is told that he is wrong and why he is wrong. He is given some additional information and is then sent back to the original frame to make another choice. This kind of programming, when used with the textbook format, is known as "scrambled text."

The question arises as to which style of programming is most effective. According to Trow[32] a program for any topic or course could contain a combination of the two procedures, using the one that is more satisfactory for any part of the content. He suggested that linear methods may be quite satisfactory for teaching facts and concepts, and branching methods are better for dealing with opinions and implications. Trow concluded that there is no final answer as to the superiority of the linear versus the branching program, and decisive experiments will be difficult.

Programed textbooks have advantages of economy and availability. They show promise of being effective in teaching perceptual-motor skills as well as knowledge.

Coleman[33] concludes from an experiment in programming the care and use of aircraft mechanics' hand tools that programed instruction can teach knowledge items more effectively than conventional instruction and also accomplish the instruction in less time. He noticed it was of particular significance that programed instruction can very effectively train students in simple manual skills.

Lang and Melton[34] found in developing a mechanical training program with the K-38 revolver that tools and equipment which are required to perform a task must be included in a program to insure its success.

An experiment by Krumboltz and Bonamitz[35] suggested that more learning will occur when the confirming response appears in its appropriate context than when it appears in isolation.

Gropper[36] found in a recent study that when a visual (pictorial) presentation of the concept to be learned preceded a verbal (print) presentation of the same concept, the learning was significantly greater and took significantly less learning time than when the verbal presentation preceded the visual one.

Gordon[37] investigated the effect of a programed textbook on student learning of 16mm motion picture projection principles and projector operation skills. His findings showed that students who used programed textbook with visuals learned principles in less time than did a lecture group. But, when the students used programed textbooks with visuals as a step toward learning projector operation, they had difficulty transferring skills information from the book to the machine. Perhaps a combination of programed textbooks and other instructional media would enhance the learning of both skills and knowledge.

Studies Related to Practice Sessions

A study by Margolius and Sheffield[38] searched for optimum methods of combining practice with filmed demonstration. They (conceptual learning). Considerable research has also been done in the area of purely motor training. Little has been done to test various means of acquiring combinations of verbal and motor development.

Loop films are widely used in schools, industry, and the armed forces. But little research has been done regarding their effectiveness in teaching concepts and high level perceptual-motor skills. Allen,[44] Meierhenry,[45] and Gerlach[46] have suggested combinations of loop films and audio information as means of making instruction more efficient. Such combinations can be utilized in polysensory systems of instruction.

There is abundant evidence that each of the components used in the polysensory instructional system developed for this study can teach. The need now is for research to determine the results of combining media and procedures in various ways.

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CHAPTER III

DESIGN AND PROCEDURES

This experiment was designed to determine the effectiveness of a polysensory instructional system for helping students acquire electric arc welding knowledges and skills. Emphasis was placed on utilizing two or more senses in the learning process. The purpose of the study was to determine results obtained by use of the polysensory system. The purpose was not to determine if the system was superior to other methods of instruction. A control group was not used because this study was not comparative. Instead, acceptable criteria were established by juries of experts, and student achievements were measured in terms of the established criteria. Comparison of the results with the established criteria necessitated that instructional procedures and information presented by the system be the same for all students.

In accord with this concept, each student worked in a laboratory setting with an instructor present at all times. The instructor functioned only to introduce the student to use of the system, to observe and record student performance, and to direct the student should performance become hazardous to him or detrimental to the equipment.

Design of the Study

This study was designed as follows:

1. A major instructional need was identified in the area of electric arc welding. The need was identified by a study of clusters of knowledges and skills widely useful in crafts and trades.[1]
2. A target population was selected.
3. Behavioral objectives were formulated.
4. Experimental instructional materials were developed. These consisted of:
   a. an instructor's guide
   b. an instruction book including programed instruction
   c. demonstration loop film with sound

    d. equipment and design for practice sessions
    e. display boards of weld examples to serve as evaluation criteria.

5. Evaluation instruments and procedures were developed. These consisted of:

    a. a knowledge pretest
    b. a performance pretest
    c. knowledge checkups
    d. performance checklists

6. The polysensory instructional system was tested.

7. The test results were analyzed and reported.

The Polysensory Instructional System

The polysensory system used in this study utilized the following media and methods:

1. Demonstration loop film to provide visual and aural information

2. Programed information for reinforcing learning initiated by the films

3. Practice sessions to develop skills

4. Weld examples to serve as reinforcement of motor skill development and as evaluation criteria.

The system was designed to facilitate instruction by providing the necessary equipment, materials, and procedures for efficient and effective learning experiences for each student. The system was developed in the following manner:

1. The behavioral objectives were established and arranged in purposeful sequence.

2. Types of learning involved in reaching each objective were identified.

3. Stimuli which would induce each type of learning were identified.

4. The stimuli served as criteria for selection of media that would be most useful in the polysensory instructional system.

5. Media were selected with regard to effectiveness of stimuli.

General Conditions

The experimental nature of the polysensory instructional system and the need for uniformity in testing the system required that general conditions be established to guide the researcher and students. These conditions were as follows:

1. Each student was provided equipment and material necessary to join two pieces of metal by the electric arc welding process.
2. Each student was responsible for use of the equipment and materials necessary to complete the unit.
3. Each student worked individually except when an introductory film was shown to the group.
4. No student was allowed to proceed in an unsafe manner or in ways detrimental to the equipment.
5. Each student was instructed to perform in such a manner as to produce a weld of quality consistent with criteria.

The researcher was available at all times to observe and record student performance.

Operational Objectives

An operational objective was established to provide an indication of results obtained by use of the system. The objective served as a basis for determining criteria for evaluating results of all instruction provided by the four parts. The following operational objective was selected: The student will acquire ability to join two pieces of steel by the electric arc welding process.

Behavioral Objectives

A thorough analysis of skills and knowledges necessary for electric arc welding provided basis for establishing criteria for behavioral objectives for the learner for each part of instruction. Source materials utilized in developing behavioral objectives are listed in Appendix A. Evaluation of student performance was based upon criteria derived from the behavioral objectives. The objectives are:

1. Part #1 -- Equipment and Safety

   The student will wear appropriate clothing while welding.

   The student will adjust the welding machine for 125 amperes.

The student will identify the electrode holder and the bare end of the welding electrode. He will place the bare end of the welding electrode in the groove of the jaws of the electrode holder.

2. Part #2 -- Striking an Arc

   The student will turn the welding machine ON before welding practice and turn it OFF after welding practice.

3. Part #3 -- Running Beads

   The student will make straight welding beads.

   The student will use a chipping hammer and wire brush to remove the slag from the weld beads and clean the metal surface.

4. Part #4 -- Fillet Weld

   The student will make a fillet weld.

Instructional Components

A combination of instructional media and objectives were selected to achieve these objectives. The following components were used:

16mm Sound-Color Film, "Fundamentals of Shielded
Arc Welding Process"

The purpose of this sound-color film was to provide the students with a general knowledge of industrial arc welding processes. This film was 25 minutes in length.

Demonstration Loop Films

Four demonstration loop films were developed in the Industrial Arts Department of Washington State University. Each film was from four to five minutes in length. Previously established behavioral objectives were utilized in establishing criteria for producing films that would teach specific knowledges and skills necessary to electric arc weld two pieces of steel together.

Each film formed a continuous loop and was enclosed in a plastic cartridge for use in the Fairchild Mark IV projector. This made it possible for each student to view the films as often as he desired without rewinding.

Skills and knowledges presented in the films were evaluated by a three-man jury of welding specialists.

Narration was recorded on the magnetic sound strips of the films to reinforce visual concepts presented in the demonstration loop films. Care was used to develop the film and sound in a manner consistent with the findings of research.

A jury of educational experts evaluated the films for consistency with accepted criteria for effective instructional film. The contents of the films are as follows:

1. Film #1 -- "Equipment and Safety"

   The primary purpose of this film was to introduce special clothing, equipment, supplies, and safety factors necessary in electric arc welding processes.

2. Film #2 -- "Striking an Arc"

   This film demonstrated the technique of striking an electric welding arc. It is necessary to establish a correct welding arc prior to performing the electric arc welding process.

3. Film #3 -- "Running Beads"

   The process of making welding beads and correct procedure for cleaning them was shown in this film. Safety was emphasized.

4. Film #4 -- "Fillet Weld"

   This film showed the equipment, materials, and skills required to make a fillet weld by the electric arc welding process.

Instruction Book

The instruction book was prepared to introduce the student to the system, to briefly outline the purpose of the system, and to provide step-by-step procedures for advancement through the system. The instruction book also provides programed instruction to reinforce the learning of knowledges and skills shown in the film.

The programed instruction is presented in four parts -- one for each of the four films. The programed instruction was developed in accord with acceptable principles and procedures.

Content, organization, and format of the programed instruction was evaluated by the jury of educational experts which evaluated the demonstration films. Revisions were made as suggested, and the book was then printed. The four parts in the instruction book were numbered and titled as follows:

Part 1 -- "Equipment and Safety"

Part 2 -- "Striking an Arc"

Part 3 -- "Running Beads"

Part 4 -- "Fillet Weld"

The programed instruction was of the linear type. The items were stated in small sequential steps so that each student would make correct responses and proceed a short distance each step. The student was directed to write appropriate words as response indicating his recall. The instruction was self-pacing, and each student proceeded at his own rate. Immediate feedback and reinforcement were provided by placing correct responses in context on the back of each page. A review test was provided at the end of each programed instruction unit. If the student encountered difficulty while completing a test, he was directed to review the films and appropriate parts of the instruction book. When he could answer all test items correctly, he proceeded to practice as directed.

Each frame in the programed instruction also included pictorial illustrations referring to the major concept introduced in that frame. The pictorial illustration preceded the verbal or printed presentation.

Practice Sessions

The purpose of practice was to provide the student with opportunity for application of knowledge and development of skills shown in the films and programed instruction books.

Practice sessions were designed to give students experience with each of the four basic processes. Upon completion of the programed instruction for each part of the unit, the student was directed to practice in a manner similar to processes shown in the films.

Safe and proper use of equipment was required at all times. These were illustrated by the films which the student had viewed. The instructor was responsible for making certain that these practices were followed.

If a student neglected to follow safety practices or began to use equipment in a detrimental manner, the instructor stopped him immediately. The student was informed why he was stopped and directed to review the appropriate film. After reviewing the film, the student proceeded with his work.

Teacher's Guide

A teacher's guide was prepared to help teachers understand the procedures utilized in the polysensory instructional system. The role of welding in modern industry and the purpose of the electric arc welding unit are briefly outlined in the guide. To assure maximum gain for all students, teachers using the system were asked to follow the procedures as outlined in the guide.

Evaluation Procedures

Pretests were used to determine facts and skills each student possessed regarding electric arc welding processes before he was provided with this instruction. There were two pretests. Both were given prior to any instruction regarding electric arc welding.

The first was a performance pretest covering tasks necessary to join two pieces of steel by the arc welding process. Complete instructions accompanied the test which was administered to individual students.

The first step of the performance test required the student to discriminate between various items and equipment necessary to make a weld bead. If the student selected the essential items, he was requested to prepare the equipment and materials for use. Students who did not select the necessary equipment and materials in the first step did not proceed to the second step.

Students correctly preparing equipment and materials for the welding operation proceeded to make a weld bead. Students producing a satisfactory weld bead during the performance pretest were not included as subjects of this study because it would be difficult to measure what they had learned from use of the system.

The knowledge pretest was administered to students who did not satisfactorily complete the performance pretest. This was an objective, multiple-choice, paper-and-pencil test consisting of thirty questions. This test covered knowledges to be taught in the self-instructional system. It was administered on a group basis. Complete instructions accompanied the test.

The instructor assured students that evaluation results would not be used to determine student grades for the course in which they are enrolled and that results would be used only to help each student learn what he needed to do next to reach his objective.

The principle of continuous evaluation is a basic element of the self-instructional system. This is an integral part of the system. The evaluation was done by the student, the instructor, or by both; but in all cases, results were immediately available to the student. The results determined whether the student proceeded to the next phase of work or repeated previous work to acquire skills and knowledge he needed to proceed.

Two forms of self-evaluation tests were used: (1) knowledge review tests and (2) performance tests.

The knowledge review tests were used to evaluate the student's knowledge of information contained in the films and programed instruction. These were incorporated into the Instruction Book and were used by the student at the end of each unit of programed instruction.

The performance tests for each instructional unit were used to evaluate the student's proficiency in performing tasks presented by the films. They were used to evaluate student's performance during and upon completion of practice sessions. A separate performance test was provided for each practice session.

The quality of welds made by students were evaluated by comparison with examples mounted on display boards. Mounted examples included correct and incorrect samples showing common errors made by beginners. The student compared his work with examples on the board and filled in a progress checklist.

Performance checklists were used to evaluate students' proficiency in learning skills and utilization of knowledge presented by the films. Satisfactory levels of performance were established for each part of the experiment by the jury of welding specialists who evaluated the instructional content of the film. It was necessary for the student to perform at this level of satisfactory performance before he was permitted to progress to the next part of the system.

One purpose of this study was to determine how much time was needed to complete the polysensory system of instruction. Therefore, the jury of educational experts decided it was not necessary to establish a maximum time limit for successful completion of the system nor was completion time considered to be a critical factor in determining the success of the system.

A film evaluation form was included in the instruction book. Participants filled out this form immediately after viewing each single-concept film. This data will contribute to revision and improvement of the system.

Administration and Use of the Polysensory Instructional System

1. Pretests were administered individually to the students.

For the performance pretest, equipment and materials necessary for performing the electric arc welding operation were made available close to the work station. Subjects were asked to select equipment and materials necessary to make a weld.

The knowledge pretest was administered individually and in groups as directed by instructions accompanying the test. The test was composed of thirty incomplete sentences and four choices of ways to complete each one correctly. From the four choices with each incomplete sentence the student selected the one he thought would complete the sentence correctly.

2. The 16mm film, "Fundamentals of Shielded Arc Welding Techniques," was shown to the group.

The purpose of this film was to provide students with a general knowledge of industrial arc welding processes. Since the purpose of this experiment was to determine what students learn from these instructional materials themselves, no advanced student preparation was given.

3. The following equipment and materials necessary for presentation of the polysensory instructional system for electric arc welding were made accessible.

    a. Instructional equipment and materials:

        Fairchild Mark IV Projector
        Demonstration loop film:
            "Equipment and Safety"
            "Striking an Arc"
            "Running Beads"
            "Fillet Weld"
        Instruction Book
        Display boards:
            Example weld beads (mounted)
            Example fillet welds (mounted)

    b. Materials, tools, and equipment for use in practice sessions:

        Lincoln A.C. "Idealarc" 250 arc Welder
        Welding leads
        Electrode holder
        Ground clamp
        Chipping hammer
        Wire brush
        Five gallon water bucket (3/4 full of water)
        Pliers
        Supply of pre-positioned steel for fillet weld
        Metal clamp
        Welding head shield with safety flip lid
        Welding gloves
        Welding apron
        Welding jacket
        Welding practice table
        Supply of welding electrodes, 1/8" E6013
        Practice steel (3/16" thick, 3" wide, and 5" long)
        Stand to position steel for fillet weld

4. The student was introduced to the system.

The instructor showed the student where the equipment and materials were assembled. Students' questions regarding materials and equipment were answered. Operation of the Fairchild projector was demonstrated. If a student had previously learned how to use the projector, he was asked to demonstrate his ability to operate it.

The student was provided the instruction book which directed him, step-by-step, how to use the system, and its use was explained by the instructor. As the student proceeded through the system, the teacher was available at all times to observe and record student performance, to answer questions or to provide help when the student could no longer proceed on his own, and to make certain the student proceeded in a safe manner.

5. The student's performance was evaluated.

Performance checklists were utilized for evaluation of each practice session. Evaluations were completed while the student was proceeding with each session.

The completed checklists were placed in envelopes bearing the student's name. The envelopes were sealed and filed for use in determining the results of the instructional system.

6. After the system was completed by each student, the equipment was cleaned and materials checked and prepared for the use of the next student.

Participants in Study

Thirty-five students participated in this study: fifteen high school industrial arts students, ten freshmen and sophomore college students, and ten adults.

The high school group was composed of six students from the Anatone, Washington, school and nine students from the Lake Oswego, Oregon, school. One student was in the ninth grade, eight were in the tenth grade, four were in the eleventh grade, and two were in the twelfth grade.

The college group was composed of ten student volunteers from Washington State University, departments of agriculture, architectural engineering, and industrial arts. Four of the group were freshmen, and six were sophomores.

The adult group was composed of ten volunteers. Two were carpenters and one was an electrician. Two were professors of education, two were professors of architectural engineering, and three were graduate teaching assistants, all at Washington State University.

Statistical Procedures

Results of numerical and verbal sections of the School and College Ability Tests and of the Differential Aptitude Tests were used to place high school students into three categories. High ability category included those from the 75 to 100 percentile; the average category included those from the 26 to 74 percentile; and the low category included those from 0 to the 25 percentile.

Results of verbal and quantitative sections of the Washington Pre-College Test Battery were used to place college students into three categories. High ability included those from the 78 to 100 percentile, average ability included those from 24 to 77 percentile, and low ability refers to those from 0 to 23 percentile.

Analysis of variance was used to test the significance of the differences between the performance of the groups. Procedure utilized for analysis of variance is described by Garrett.[2] It compares resulting variance ratios with F values in an appropriate F table.[3]

Results of the system were analyzed to determine observable differences between the three groups and between high, average, and low ability students. Data recorded on tables and analyzed included: performance pretest scores, knowledge pretest scores, performance scores, knowledge review test scores, time needed to acquire knowledges and develop skills in each part, total time needed to satisfactorily complete the instructional system, number of times the films were reviewed, and mistakes made in use of the programed instruction.

Limitations

1. Only high school students enrolled in industrial arts classes were included in this study. The college and adult groups were composed entirely of volunteers. Numbers of high school and college students in the high, average, and low ability levels were not equal.

2. There was no way of controlling student learning outside of the instructional system between practice sessions. However, the equipment necessary for skill development was not readily available to participants outside the system.

3. Levels of interest and motivation may have varied between participants.

Footnote References -- Chapter III

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CHAPTER IV

FINDINGS

All participants reached the predefined level of performance established by the jury as representing competence. Time used to complete the instructional system varied between the three groups -- high school students, college students, and adults. Time used also varied between individuals within the adult group and between individuals of high, average, and low ability in the high school and college groups.

An analysis of variance as described by Garrett[1] was used to test the significance of the differences between means of total time to complete the instructional system for the three groups.

A summary of analysis of variance for all groups presented in Table 1 shows the calculated F is larger than the F in the column of scores from Table F.[2] This indicates that the means of the high school, college, and adult groups do in fact differ by a significant amount.

The F score calculated for all groups furnished a comprehensive or overall test of the significance of the difference among means for the three groups. This F score does not tell which means differ significantly, therefore, an analysis of variance was used to test the significance of the differences between means of total time to complete the instructional system for the high school and college group, for the high school and adult group, and for the college and adult group.

TABLE 1

SUMMARY: ANALYSIS OF VARIANCE OF TIME USED BY ALL GROUPS TO COMPLETE INSTRUCTIONAL SYSTEM

Source of Variation	df	Sum of Squares	Mean Square (Variance)	F	From Table F for df_1 2 and df_2 32
Among the Means of Groups	2	309,468.817	154,734,4085	13.56	F at .05 3.29 F at .01 5.34
Within Groups	32	399,378.333	11,410.8384		
Total	34	708,847.150	...		

Summary of analysis of variance for the high school and college groups presented in Table 2 shows the calculated F is considerably larger than the F in the column of scores from Table F.[3] This indicates that the means of the high school and college groups are significantly different at the .05 and .01 levels.

Summary of analysis of variance for the high school and adult groups presented in Table 3 shows the calculated F is much greater than the F in the column of scores from Table F.[4] This reveals that the means of the high school and adult groups are significantly different at the .05 and .01 levels.

Summary of analysis of variance for college and adult groups illustrated in Table 4 shows the calculated F is much smaller than the F in the column of scores from Table F.[5] This indicates that there is no significant difference between means of total time to complete the instructional system for the college and adult groups.

TABLE 2

SUMMARY: ANALYSIS OF VARIANCE OF TIME USED BY HIGH SCHOOL AND COLLEGE GROUPS TO COMPLETE INSTRUCTIONAL SYSTEM

Source of Variation	df	Sum of Squares	Mean Square (Variance)	F	From Table F for df_1 1 and df_2 23
Between Means	1	199,108.167	199,108.167	12.43	F at .05 4.28 F at .01 7.88
Within Groups	23	368,325.833	16,014.166		
Total	24	567,434.000	...		

TABLE 3

SUMMARY: ANALYSIS OF VARIANCE OF TIME USED BY HIGH SCHOOL AND ADULT GROUPS TO COMPLETE INSTRUCTIONAL SYSTEM

Source of Variation	df	Sum of Squares	Mean Square (Variance)	F	From Table F for df_1 1 and df_2 23
Between Means	1	233,248.167	233,248.167	15.45	F at .05 4.28 F at .01 7.88
Within Groups	23	347,175.833	15,094.601		
Total	24	580,424.000	...		

TABLE 4

SUMMARY: ANALYSIS OF VARIANCE OF TIME USED BY COLLEGE AND ADULT GROUPS TO COMPLETE INSTRUCTIONAL SYSTEM

Source of Variation	df	Sum of Squares	Mean Square (Variance)	F	From Table F for df_1 1 and df_2 18
Between Means	1	1,125	1,125	.243	F at .05 4.41 F at .01 8.28
Within Groups	18	83,255	4,625.28		
Total	19	84,380	...		

As noted in Chapter I, low ability high school students are those whose combined scores on the verbal and numerical section of Differential Aptitude Tests or on the Verbal Quantitative sections of the School and College Ability Tests were from the 0 to 25 percentile. Low ability college students are those whose composite scores on the Verbal and Quantitative Washington Pre-College Test Battery were from the 0 to 23 percentile. Average ability high school students are those whose scores were from the 26 to 74 percentile and average ability college students are those scoring in the 24 to 77 percentile. High ability high school students are those whose scores were in the 75 to 100 percentile and high ability college students were in the 78 to 100 percentile.

Table 5 presents the participant scores on the performance pretest. Observed scores on the performance pretest indicated that the students selected as subjects for this study did not possess the capability to join two pieces of steel by the electric arc welding process. Some participants selected correct items involved in work of this unit; however, they were unable to get the equipment and materials ready and run a welding bead. The majority of participants made no attempt to make a welding bead. They simply stated they did not have the capabilities necessary to proceed.

Table 6 presents the participant scores on the 30-item knowledge pretest. Observed scores on the knowledge pretest indicate that most of the participants possessed some prior knowledges of the electric arc welding process. Participants were requested to refrain from guessing so that the scores would indicate true evaluations of previous knowledges. The questions utilized in the knowledge pretest involved the beginning operations of the welding process so that it would be expected that previous exposure to equipment and materials would have provided participants with enough general knowledge to obtain a fairly high score.

TABLE 5

PERFORMANCE PRETEST SCORES

Ability	Scores				Total Participants
	0-9	10-27	28-36	37-45	
	Number of High School Students				
High	7	...	...	...	7
Average	5	...	...	...	5
Low	3	...	...	...	3
Total	15	...	...	...	15
	Number of College Students				
High	1	...	...	...	1
Average	7	...	...	...	7
Low	2	...	...	...	2
Total	10	...	...	...	10
	Number of Adults				
Untested	10	...	...	...	10
	Total				
...	35	...	...	...	35

It was evident, however, from item analysis that the participants did not possess the more specific, technical knowledges necessary for successful completion of the instructional system. This was supported further by participants' low scores on the performance pretest.

Total scores obtained on knowledge review tests at the conclusion of the programed instruction in each of the four parts are tabulated in Table 7. When participants missed an item, they were directed to review the appropriate materials until they could complete all items correctly. However, their initial score is the one tabulated on Table 7.

The observed knowledge scores do not indicate a major variation between groups of participants or between ability levels within groups. All participants were quite successful in the knowledge review tests with only one high school student and one adult missing more than one item.

TABLE 6

KNOWLEDGE PRETEST SCORES

Ability	Scores																						Total Participants
	0	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
	Number of High School Students																						
High	..	..	..	..	..	..	1	..	..	1	1	1	2	1	..	..	..	..	..	..	..	..	7
Average	..	..	..	..	..	..	..	2	..	1	..	..	..	..	..	1	..	..	1	..	..	..	5
Low	..	..	1	..	..	..	..	..	..	..	..	1	..	1	..	..	..	..	..	..	..	..	3
Total	..	..	1	..	..	..	1	2	..	2	1	2	2	2	..	1	..	..	1	..	..	..	15
	Number of College Students																						
High	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	1
Average	1	..	..	..	..	1	3	..	..	..	1	..	..	..	..	..	..	1	..	..	..	..	7
Low	..	1	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2
Total	1	1	..	..	..	2	3	..	..	..	1	..	..	..	1	..	..	1	..	..	..	..	10
	Number of Adults																						
Untested	..	..	1	..	1	1	..	..	..	..	2	3	1	..	..	..	1	..	..	..	..	..	10
	Total																						
...	1	1	2	..	1	3	4	2	..	2	4	5	3	2	1	1	1	1	1	..	..	..	35

TABLE 7

KNOWLEDGE REVIEW TEST SCORES

Ability	Scores				Total Participants
	27	28	29	30	
Number of High School Students					
High	..	..	1	6	7
Average	..	..	2	3	5
Low	..	1	1	1	3
Total	..	1	4	10	15
Number of College Students					
High	..	..	..	1	1
Average	..	..	3	4	7
Low	..	..	1	1	2
Total	..	..	4	6	10
Number of Adults					
Untested	1	..	3	6	10
Total					
...	1	1	11	22	35

Table 8 presents the total performance score for the participants' electric arc welding practice sessions. The jury determined satisfactory performance levels for each part of the instructional system. As each participant reached this level of performance for each part, he was directed to proceed to the next. But no one could proceed to any part until he had reached the satisfactory level of performance on the preceding part. Therefore, performance scores are the same for each participant.

Time Used for Completion of Instructional System

Table 9 presents the amount of time utilized by participants for completion of Part One, Equipment and Safety. The tabulated times include film viewing, use of the Instruction Book, and practice sessions.

TABLE 8

TOTAL PERFORMANCE SCORES

Ability	Acceptable level of performance--45	Total Participants
Number of High School Students		
High	7	7
Average	5	5
Low	3	3
Total	15	15
Number of College Students		
High	1	1
Average	7	7
Low	2	2
Total	10	10
Number of Adults		
Untested	10	10
Total		
...	35	35

The range of times used to complete Part One was from 20 to 45 minutes. The average time was 31 minutes for the three groups. Observations indicate that time used to complete Part One varied as much between groups as between ability levels of the high school and college students. The tasks involved in Part One called for development of simple motor skills which required a relatively low amount of time from all groups.

Table 10 presents the amounts of time utilized by participants for completion of Part Two, Striking an Arc. The time indicated includes film viewing, use of the Instruction Book, and practice sessions.

TABLE 9

TIMES USED TO COMPLETE PART 1 (EQUIPMENT AND SAFETY)*

Ability	Times				Total Participants
	0:20	0:30	0:35	0:45	
Number of High School Students					
High	1	3	2	1	7
Average	1	3	1	..	5
Low	1	..	1	1	3
Total	3	6	4	2	15
Number of College Students					
High	..	..	1	..	1
Average	2	2	2	1	7
Low	..	1	..	1	2
Total	2	3	3	2	10
Number of Adults					
Untested	1	7	2	..	10
Total					
...	6	16	9	4	35

*Time tabulated in hours:minutes to the nearest five minutes.

The time needed to complete Part Two varied from 20 minutes to one hour. The average was 31 minutes for the three groups. The tasks in this part are more difficult and require more time for the high school and college students than the adult group.

Table 11 presents the amounts of time used by participants for completion of Part Three, Running a Bead. The tabulated times include film viewing, use of the Instruction Book, and practice sessions.

The minimum time was 1 hour, 50 minutes; maximum time was 9 hours, 20 minutes. The average was four hours for all groups. High school students required more time to reach satisfactory levels of performance than the college and adult groups. The average time for the high school group was 5 hours; for the college group it was 2 hours, 58 minutes; and for the adult group it was 3 hours, 22 minutes.

TABLE 10

TIMES USED TO COMPLETE PART 2
(STRIKING AN ARC)*

Ability	Times						Total Participants
	0:20	0:30	0:35	0:45	0:50	1:00	
Number of High School Students							
High	1	5	..	..	1	..	7
Average	1	3	..	..	..	1	5
Low	..	1	..	..	2	..	3
Total	2	9	..	..	3	1	15
Number of College Students							
High	..	1	..	..	..	..	1
Average	1	4	..	2	..	..	7
Low	..	2	..	..	..	..	2
Total	1	7	..	2	..	..	10
Number of Adults							
Untested	1	8	1	..	..	..	10
Total							
...	4	24	1	2	3	1	35

*Time tabulated in hours:minutes to the nearest five minutes.

The maximum time for any participant in the first two parts was 1 hour for Part Two. The maximum time of 9 hours, 20 minutes required for Part Three, Running a Bead, indicates the higher level of perceptual-motor skill developed in this part. (See Table 11)

Table 12 presents the amounts of time used to complete Part Four, Fillet Weld. The tabulated times include film viewing, use of the Instruction Book, and practice sessions.

Amounts of time used to complete Part Four ranged from 20 minutes to 3 hours, 10 minutes. The average time used by all groups to complete Part Four was 1 hour, 10 minutes. The average time for the high school group was 1 hour, 30 minutes with the longest time being 3 hours, 10

TABLE 11

TIMES USED TO COMPLETE PART 3 (RUNNING A BEAD)*

Ability	Times																									Total
	1:50	1:55	2:15	2:20	2:30	2:40	2:50	3:05	3:15	3:20	3:30	3:35	4:05	4:25	4:30	4:35	5:05	5:10	5:15	5:30	6:10	6:30	7:20	9:00	9:20	
Number of High School Students																										
High	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	2	-	1	-	1	1	7
Average	-	-	-	-	-	-	-	1	-	-	1	-	-	-	1	-	1	1	-	-	-	-	-	-	-	5
Low	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	3
Total	-	-	-	-	-	-	-	1	1	1	1	-	-	-	1	-	1	2	1	2	-	1	1	1	1	15
Number of College Students																										
High	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Average	-	1	-	2	1	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	1	-	-	-	-	7
Low	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Total	1	2	-	2	1	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	1	-	-	-	-	10
Number of Adults																										
Untested	1	-	1	1	-	1	1	-	-	-	-	1	1	1	-	1	1	-	-	-	-	-	-	-	-	10
Total																										
---	2	2	1	3	1	1	1	1	1	1	3	2	1	1	1	1	2	2	1	2	1	1	1	1	1	35

*Time tabulated in hours:minutes to the nearest five minutes.

minutes used by a high ability student. The shortest time in the high school group was 40 minutes for an average ability student.

The college students used an average of 1 hour. Seven of the ten students in this group used less time than the average for all groups. The shortest time used in this group was 35 minutes by one average ability and one low ability student.

Time for adults ranged from 20 minutes to 50 minutes. The average adult time was 37 minutes. All adults completed this part in less than the average time used by all groups.

Table 13 presents the total amounts of time required to complete Parts One, Two, Three, and Four. The tabulated times include film viewing, use of the Instruction Book, and practice sessions. Amounts of time to complete the instructional system ranged from 3 hours, 30 minutes to 13 hours, 10 minutes. The average total time for all groups to complete the instructional system was 6 hours, 8 minutes.

The time needed for the high school group to complete the system varied from 4 hours, 55 minutes to 13 hours, 10 minutes. This group averaged 8 hours, 5 minutes.

The high ability high school students used from 5 hours, 10 minutes to 13 hours, 10 minutes to complete the work. Their average was 8 hours, 6 minutes. One of the seven high school students rated as high ability completed the work in less than the average total time, but the remaining six high ability high school students required considerably more time.

Average ability high school students used from 4 hours, 55 minutes to 8 hours, 35 minutes to complete the work. Average time for this group was 6 hours, 26 minutes. Two average ability high school students completed the system in less time than the average total time, one required only two minutes more than average total time, and the remaining two average ability high school students required considerably more time.

The low ability students used from 6 hours, 30 minutes to 11 hours, 25 minutes to complete the work. The three low ability students in the high school group used more than the average total times but did not reach the level of time required by the two slowest high ability students.

College students used from 3 hours, 30 minutes to 8 hours to complete the instructional system. Average time for college students was 5 hours, 1 minute. College students were more consistent in time used to complete the work. Only one college student used more than the average total times for all groups to complete the work.

Adults used from 3 hours, 35 minutes to 6 hours, 40 minutes to complete the system. Average time for adults was 4 hours, 59 minutes. Eight of the ten in this group used less time than the average total time for all groups.

TABLE 12

TIMES USED TO COMPLETE PART 4 (FILLET WELD)*

Ability	Times																Total
	0:20	0:30	0:35	0:40	0:45	0:50	1:05	1:10	1:20	1:30	1:35	1:40	2:05	2:10	2:30	3:10	
Number of High School Students																	
High	-	-	-	-	1	1	1	-	-	-	1	1	1	-	-	1	7
Average	-	-	-	1	1	-	-	2	-	-	-	-	-	1	-	-	5
Low	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	-	3
Total	-	-	-	1	2	1	1	2	-	-	1	1	3	1	1	1	15
Number of College Students																	
High	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Average	-	-	1	1	-	1	2	-	1	1	-	-	-	-	-	-	7
Low	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	2
Total	-	-	2	2	-	1	2	-	1	1	1	-	-	-	-	-	10
Number of Adults																	
Untested	1	2	3	1	1	2	-	-	-	-	-	-	-	-	-	-	10
Total																	
---	1	2	5	4	3	4	3	2	1	1	2	1	3	1	1	1	35

*Time tabulated in hours:minutes to the nearest five minutes.

TABLE 13

TOTAL TIMES USED TO COMPLETE THE SYSTEM*

Ability	Times																															Total
	3:30	3:35	3:40	3:45	4:00	4:10	4:25	4:35	4:40	4:55	5:05	5:10	5:15	5:35	5:40	5:45	5:55	6:10	6:25	6:30	6:40	7:15	7:55	8:00	8:10	8:25	8:35	8:40	11:25	12:05	13:10	
Number of High School Students																																
High	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	1	-	1	-	-	1	-	1	1	7
Average	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	1	-	-	-	1	-	-	-	-	1	-	-	-	-	5
Low	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	1	-	-	3
Total	-	-	-	-	-	-	-	-	-	1	-	1	1	-	-	-	-	1	-	1	-	2	1	-	1	1	1	1	1	1	1	15
Number of College Students																																
High	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Average	-	-	1	-	-	-	1	1	-	1	-	-	-	1	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	7
Low	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Total	1	-	1	-	-	-	1	1	1	1	-	-	1	1	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	10
Number of Adults																																
Untested	-	1	-	1	1	1	1	-	-	-	1	-	-	-	-	1	1	-	1	-	1	-	-	-	-	-	-	-	-	-	-	10
Total																																
---	1	1	1	1	1	1	2	1	1	2	1	1	2	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	35

*Time tabulated in hours:minutes to the nearest five minutes.

Observations of results indicate that high, average, and low ability high school students differ greatly in the amount of time necessary to complete the work in this instructional system. College students of high, average, or low ability did not vary as greatly as to amount of time needed to complete the work; however, there was only one high ability college student in the group.

The greatest variation appeared between the groups of high school, college, and adult participants. The college and adult groups required considerably less time to reach satisfactory levels of performance than did the high school group. More than 67 per cent of the high school group used more time than the average time for all groups. Whereas, 15 per cent of the college and adult groups used more time than the average total time for all groups. It would appear that age level rather than ability level is a more important factor in regard to time used in completing the instructional system.

Frequency of Film Viewing

Table 14 presents the frequency of film viewing during participation in the instructional system.

There was a large variation in the number of times the participants viewed the films, with an average total for all groups of almost six times for the four films. Film viewing varied from a minimum of one time for each of the four films to a maximum of three and one-half times for each of the four films.

High school students of high ability viewed the films more times than those of average or low ability high school students. Four out of seven high ability high school students viewed the films more times than the average viewing for all groups.

High school students of average ability viewed the films from four to six times. Four of the five average high school students viewed the films less than the average for all participants.

Two low ability high school students viewed the films four times or one time for each film. One low ability high school student viewed the films more than the average for all participants -- a total of eight viewings.

The one high ability college student viewed the films a minimum number of times or one viewing for each film.

The average ability college student viewed the films from five to nine times, with two students viewing the films less than the average for all groups, and three students viewing the films more.

One college student of low ability viewed the films less than the average for all groups.

Nine of the ten adults viewed the films less than the average for all groups. As the participants proceeded through the instructional system, it was noted that high school students viewed the films more often than college students, and college students viewed the films more often than the adults.

TABLE 14

FREQUENCIES OF FILM VIEWING*

Ability	Frequencies								Total
	4	5	6	7	8	9	11	14	
Number of High School Students									
High	1	2	1	-	1	-	1	1	7
Average	2	2	1	-	-	-	-	-	5
Low	2	-	-	-	1	-	-	-	3
Total	5	4	2	-	2	-	1	1	15
Number of College Students									
High	1	-	-	-	-	-	-	-	1
Average	-	2	2	2	-	1	-	-	7
Low	-	1	1	-	-	-	-	-	2
Total	1	3	3	2	-	1	-	-	10
Number of Adults									
Untested	4	5	1	-	-	-	-	-	10
Total									
---	10	12	6	2	2	1	1	1	35

*Total viewing of four films.

Student Errors in Programed Instruction Book

Table 15 presents the total number of student errors in the programed Instruction Book. When an error was made, the participant made the proper correction, then continued with the instruction. The original responses were recorded and tabulated in Table 15.

Errors made by all participants during completion of the programed Instruction Book totaled sixteen.

Four high school students of high ability made no errors. Two students made one error, and one student made four.

Three high school students of average ability made no errors. One student made one error, and another made two errors.

Two low ability high school students made one error, and another made three. There appears to be no pattern of relationships between errors and high school ability groups.

All of the college students completed the programed instruction with no errors.

Eight adults completed the programed instruction with no errors. Two adults made one error.

College students and adults made fewer errors than high school students.

TABLE 15

NUMBER OF STUDENT ERRORS MADE DURING USE OF THE
PROGRAMED INSTRUCTION BOOK

Ability	Number of Errors						Total
	0	1	2	3	4		
Number of High School Students							
High	4	2	-	-	1		7
Average	3	1	1	-	-		5
Low	-	2	-	1	-		3
Total	7	5	1	1	1		15
Number of College Students							
High	1	-	-	-	-		1
Average	7	-	-	-	-		7
Low	2	-	-	-	-		2
Total	10	-	-	-	-		10
	Number of Adults						
Untested	8	2	-	-	-		10
	Total						
---	25	7	1	1	1		35

Film Evaluation by Students

At the conclusion of each film viewing, the student was directed to evaluate the film. A Form for this evaluation was included in the Instruction Book. Each student was requested to rate the film to his liking of it, its length, ease of comprehension, speed, sound, and readability.

Responses indicate that 98 per cent liked the films. The frequency distribution of these responses is shown in Table 16.

TABLE 16

FREQUENCY DISTRIBUTION OF STUDENTS
LIKING AND DISLIKING FILMS

Response	High School				College				Adults				Totals
	Film No.				Film No.				Film No.				
	1	2	3	4	1	2	3	4	1	2	3	4	
I liked the film	15	14	15	14	10	10	10	10	10	10	10	10	138
I didn't like the film	-	1	-	1	-	-	-	-	-	-	-	-	2

Single-concept films provide opportunity to concentrate instruction in short time spans. Ninety per cent of the respondents indicated that the length of time was satisfactory. The frequency distribution of respondents' views regarding length of the single-concept film is shown in Table 17.

TABLE 17

FREQUENCY DISTRIBUTION OF STUDENT RESPONSES
EVALUATING LENGTH OF FILMS

Response	High School				College				Adults				Totals
	Film No.				Film No.				Film No.				
	1	2	3	4	1	2	3	4	1	2	3	4	
Too long	-	1	-	-	-	1	-	1	-	-	-	-	3
Too short	1	3	2	2	-	-	-	-	-	-	1	-	9
Correct Length	14	11	13	13	10	9	10	9	10	10	9	10	128

Eight high school students and one adult indicated that the films were too short. One high school student and one college student suggested a feeling that the films were too long.

Instruction presented in the single-concept film was comprehensible. Twelve high school group respondents indicated the film mediated instruction was too easy. Ninety per cent of all responses indicated the level of difficulty was about right. No respondents indicated excessive difficulty.

The frequency distribution of responses concerning difficulty is shown in Table 18.

TABLE 18

FREQUENCY DISTRIBUTION OF STUDENT RESPONSES EVALUATING DIFFICULTY OF FILM MEDIATED INSTRUCTION

Response	High School				College				Adults				Totals
	Film No.				Film No.				Film No.				
	1	2	3	4	1	2	3	4	1	2	3	4	
Too difficult	-	-	-	-	-	-	-	-	-	-	-	-	---
About right	13	10	13	12	9	10	10	10	10	10	10	10	127
Too easy	2	5	2	3	1	-	-	-	-	-	-	-	13

Three responses from the high school group indicated the films moved too fast and three responses from this same group indicated the films went too slow. All other responses show that participants considered the films moved at the right speed.

The frequency distribution of responses concerning the speed of the mediated instruction is shown in Table 19.

TABLE 19

FREQUENCY DISTRIBUTION OF STUDENT RESPONSES EVALUATING SPEED OF FILM MEDIATED INSTRUCTION

Response	High School				College				Adults				Totals
	Film No.				Film No.				Film No.				
	1	2	3	4	1	2	3	4	1	2	3	4	
Too fast	-	1	1	1	-	-	-	-	-	-	-	-	3
Right speed	15	13	13	13	10	10	10	10	10	10	10	10	134
Too slow	-	1	1	1	-	-	-	-	-	-	-	-	3

Nine high school students indicated difficulty in understanding the films verbal presentations. Three college students and two adults also had problems. Ninety per cent of all responses indicated the sound was clear and easy to understand.

The frequency distribution of responses concerning the sound is shown in Table 20.

TABLE 20

FREQUENCY DISTRIBUTION OF STUDENT RESPONSES EVALUATING DIFFICULTY COMPREHENSION OF SOUND

Response	High School				College				Adults				Totals
	Film No.				Film No.				Film No.				
	1	2	3	4	1	2	3	4	1	2	3	4	
Very clear and easy to understand	12	14	13	12	8	9	10	10	10	9	10	9	126
Difficult to understand	3	1	2	3	2	1	-	-	-	1	-	1	14

Participants evaluated the ease with which they could read printed words used in the films. Almost 99 per cent of the responses indicated that the words were easy to read.

Frequency distribution showing responses evaluating difficulty of reading words is shown in Table 21.

TABLE 21

FREQUENCY DISTRIBUTION OF STUDENT RESPONSES EVALUATING EASE OF READING WORDS ON FILMS

Response	High School				College				Adults				Totals
	Film No.				Film No.				Film No.				
	1	2	3	4	1	2	3	4	1	2	3	4	
Easy to read	15	15	15	15	9	10	10	10	9	10	10	10	138
Difficult to read	-	-	-	-	1	-	-	-	1	-	-	-	2
Couldn't read	-	-	-	-	-	-	-	-	-	-	-	-	---

Analysis of this data indicates very little association between ability levels of students and student response to the six film evaluation measures.

Footnote References -- Chapter IV

[1] Garrett, pp. 276-308.

[2] *Ibid.*, p. 453.

[3] *Ibid.*, p. 452.

[4] *Ibid.*

[5] *Ibid.*

CHAPTER V

SUMMARY AND CONCLUSIONS

Results

All participants reached levels of performance as predefined as satisfactory by the jury of welding experts.

Prior to use of the instructional system, participants possessed few or no electric arc welding skills.

Prior to use of the instructional system, participants possessed some knowledges utilized in performing the electric arc welding process. The average score for all participants on the knowledge pretest was 17.8 correct responses, a percentage of 59 per cent. Upon completion of the instructional system, the average score of all participants in the knowledge review tests was 29.5 correct responses, a percentage of 98.3 per cent. This is a 65 per cent average gain upon completion of the system.

Time used by individual students to reach predefined levels of performance ranged from 3 hours, 30 minutes to 13 hours, 10 minutes. The average was 5 hours and 10 minutes.

Time used to complete the system varied between and within ability levels and groups. College and adult groups required less time than the high school group to complete the instructional system.

Frequency of film viewing varied between and within groups. The adult group viewed the films least often. In the high school group, high ability level students viewed the films most often.

Errors in use of programed instruction varied. The high school group made 14 errors, the college group made no errors, and the adult group made two errors.

All subjects gained in knowledge.

Interpretations and Conclusions

Results of this study indicate that the polysensory instructional system was effective in teaching knowledges and high level perceptual-motor skills involved in electric arc welding. Acceptable levels of performance were reached by all participants which suggests that general mental ability appeared to be an irrelevant factor in learning arc welding skills.

By use of this instructional system, high school students acquired these particular knowledges at varying rates of speed and also developed these performance skills at various rates. This seems to indicate a need for flexibility in such instruction at various levels of student ability.

The fact that college and adult groups reached satisfactory performance levels in considerably shorter time than the high school group implies a need for flexibility of instruction to meet need of various age groups.

Frequency of film viewing by high school students varied within and between ability level groups. The fact that the higher ability students viewed the films a greater number of times may indicate a stronger need to perform at a high level. Such students may also have developed repetitive habits as a result of previous instructional experiences.

The fact that all participants indicated they considered the programed instruction an essential component of the instructional system and that the system would have been less effective without it, supports the concept of instructional systems comprised of components each of which contributes a function and reinforces the others.

Results of student performance indicate that in substantial degrees, students can evaluate their own progress in developing manipulation skills, provided they are familiar with the criterion of acceptable performance. They can also diagnose difficulties encountered in development of skills and make appropriate adjustments to improve their performance. The fact that participants independently evaluated, improved, and then completed their work supports the feasibility of self-evaluation in development of skills.

Recommendations

An instructor should be available to help students overcome individual learning problems which may prevent normal progress in learning high level perceptual-motor skills. A student may only need the moral support of an instructor being close at hand. However, in learning high level perceptual-motor skill such as electric arc welding, it may be necessary for the instructor to grasp the student's hand and help him run a welding bead. By giving this assistance, the instructor may be providing the stimulus necessary for the student to develop proper insight into this manipulative operation which will enable the student to reach a satisfactory level of performance. The instructor should also be alert to the possibility that some students may be inclined to by-pass portions of the instructional system. When this occurs, students encounter difficulty in completing the instructional system or do not complete it at all.

The system should be tested with controlled groups to ascertain more precisely the strength of this approach to instruction.

Systems utilizing other types of components organized to teach for similar objectives should be developed.

Additional research should be designed to test the strength and instructional values of various components of this instructional system.

Such systems should be tested in schools, job corps, industry, and adult educational programs.

Interaction between students should be build into systems and evaluated for effectiveness.

Implications

Results of this study indicate the practability of utilizing polysensory instructional systems for learning of high level perceptual-motor skills and knowledges. Such self-pacing systems allow each student to progress at his own best rate with a minimum of involvement by the instructor. Results also indicate that individuals will accept responsibility for advancement in learning processes if provided the opportunity.

Implementation of systems of instruction could modify the role of the instructor. The instructor may become a leader, diagnostician, counselor, and manager of instruction. Considerably less time would be spent in preparation and presentation of instructional material because the system would transmit to students more of the materials and procedures necessary for learning.

By utilizing systems of instruction, instructors can have more time for:

1. Helping students overcome individual learning problems which may be preventing normal progress in the learning process.
2. Providing leadership for small and large group activities.
3. Developing and preparing supplementary instructional materials.
4. Manipulating the educational environment to increase the student's opportunities for further development of concepts and skills.

Adaptation and utilization of the systems approach also has implications for planning industrial education facilities. Individual and small group instructional areas would need to be located so as to provide easy student access to equipment and materials of an instructional resource center. Design of facilities should encourage flexibility and change for adaptation to evolving educational technology.

Development and utilization of instructional systems such as the one tested in this study also have implications for:

1. Grading and classification of students. Grading as it is known can be eliminated because students' performance will be evaluated as satisfactory upon reaching established criterion levels of achievement. Students can advance at their own pace.

2. Improving adult education programs. Systems of instruction may be utilized to upgrade undertrained workers and retrain displaced workers.

3. Curriculum development. Educational programs would be prepared by experts and used only after lengthy tryout and revision.

4. Teacher-training. Teacher-training institutions and others in education will adjust to the fact that "instructional staff" includes both ends of the mediation process. There will be a reshuffling and reassignment of personnel; technology will force the transfer of classroom teachers from one side of mediation to the other. A large portion of the teaching profession may become engaged in preparing instructional materials with little, or no, direct face-to-face contact with students.

5. Development of more flexibility. Instruction can better be adapted to the abilities and needs of the learner. Traditional lockstep classes can be eliminated and more instruction can be available where and when it is needed to meet students' interests.

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APPENDIX A

SOURCES OF FACTS USED FOR FORMULATING BEHAVIORAL OBJECTIVES

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